How to Build an Astrolabe

RESOURCE PACK

Contents of this pack:

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http://www.joh.cam.ac.uk/library/library_exhibitions/schoolresources/astrolabe/

How to Build an Astrolabe

History and Background

Astrolabes are an ancient astronomical instrument. They were first used in ancient Greece, were extensively developed in the medieval Islamic world and became the key astronomical instrument of the western middle ages.

When mapping the heavens astronomers assume that the stars seen in the night sky are all at an equal distance from the earth, fixed on the inside of an enormous sphere that has the earth at its centre. By using this model, they can create the two-dimensional representation of this celestial sphere seen on star charts and astrolabes, the starry equivalent of a map of the earth.

The front of the medieval astrolabe shows a map of the night sky on the rotating rete. Its name is taken from the Latin word for 'net', because of the appearance of the spikes which indicated the positions of individual stars. The rete also shows the path of the sun against the background stars; this path is known as the ecliptic, and the constellations through which the sun passes on the ecliptic are the well-known signs of the Zodiac. The modern astrolabe used in this kit uses a sheet of transparent acetate for the rete, with the position of stars indicated by dots. The brightness of the star is shown by the size of the dot: the larger the dot, the brighter the star.

Beneath the rete of the medieval astrolabe sits a plate inscribed with a projection of sky above an observer at a given latitude: the plate could be removed and replaced with others calibrated for different latitudes if necessary. The plate and the rete nest inside the body (or womb) of the astrolabe, called the mater, which is inscribed on its outer edge, or limb, with scales of degrees and hours. Fixed to the centre of the astrolabe is a rotating rule used for taking readings. In this astrolabe kit, the plate is, for simplicity, integrated into the mother. The astrolabe is calibrated for latitude 52° North, the latitude of Cambridge and its surroundings.

On the back of the astrolabe is a rotating bar called the alidade or label, which is used to measure the altitude above the horizon of celestial bodies. This side of the instrument is divided into degrees for taking altitude measurements, and is also engraved with a calendar and divisions of the zodiac.

By using the data from both sides of the instrument and the measured positions of objects in the sky, the user of the astrolabe can calculate many facts about their position in time and space, including the hour of the day, the date, and their position on the earth's surface.

The St John's College Library online astrolabe resource has links to several museum collections with photographs of astrolabes:
http://www.joh.cam.ac.uk/library/library_exhibitions/schoolresources/astrolabe/info/

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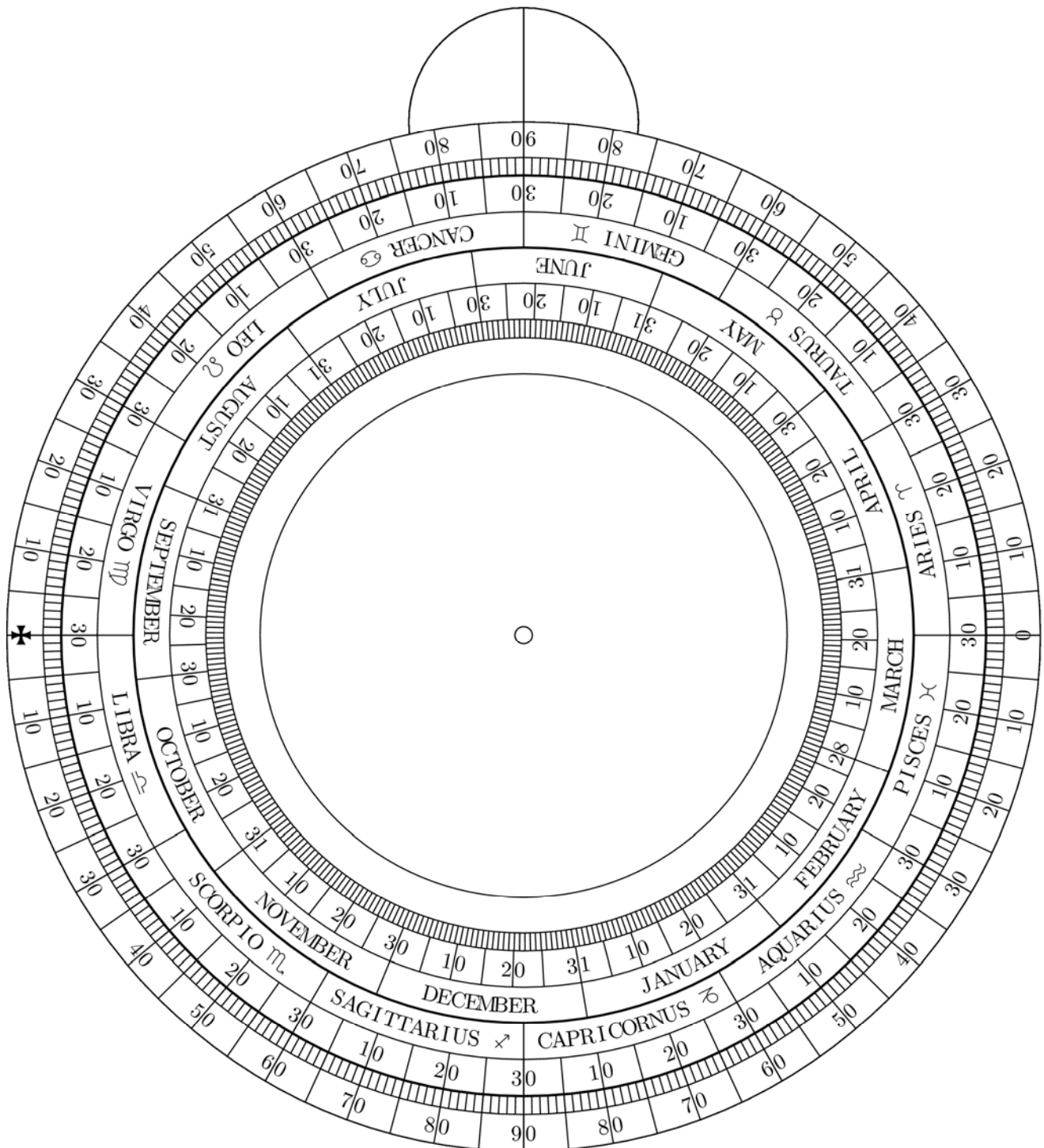
Astrolabe template page 1: Mother, back

Print this page on thin card.

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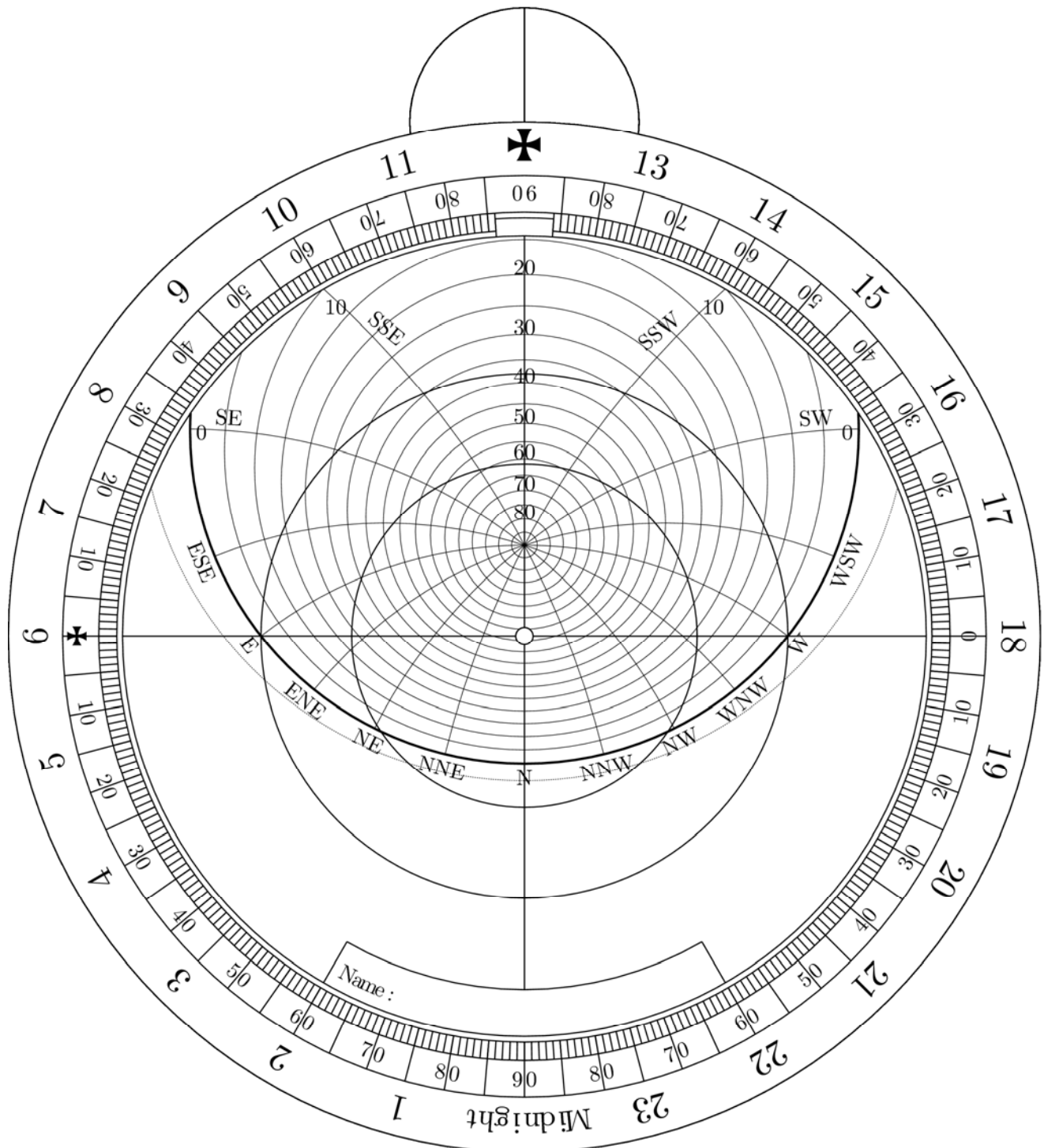
Astrolabe template page 2: Mother, front

Print this page on thin card

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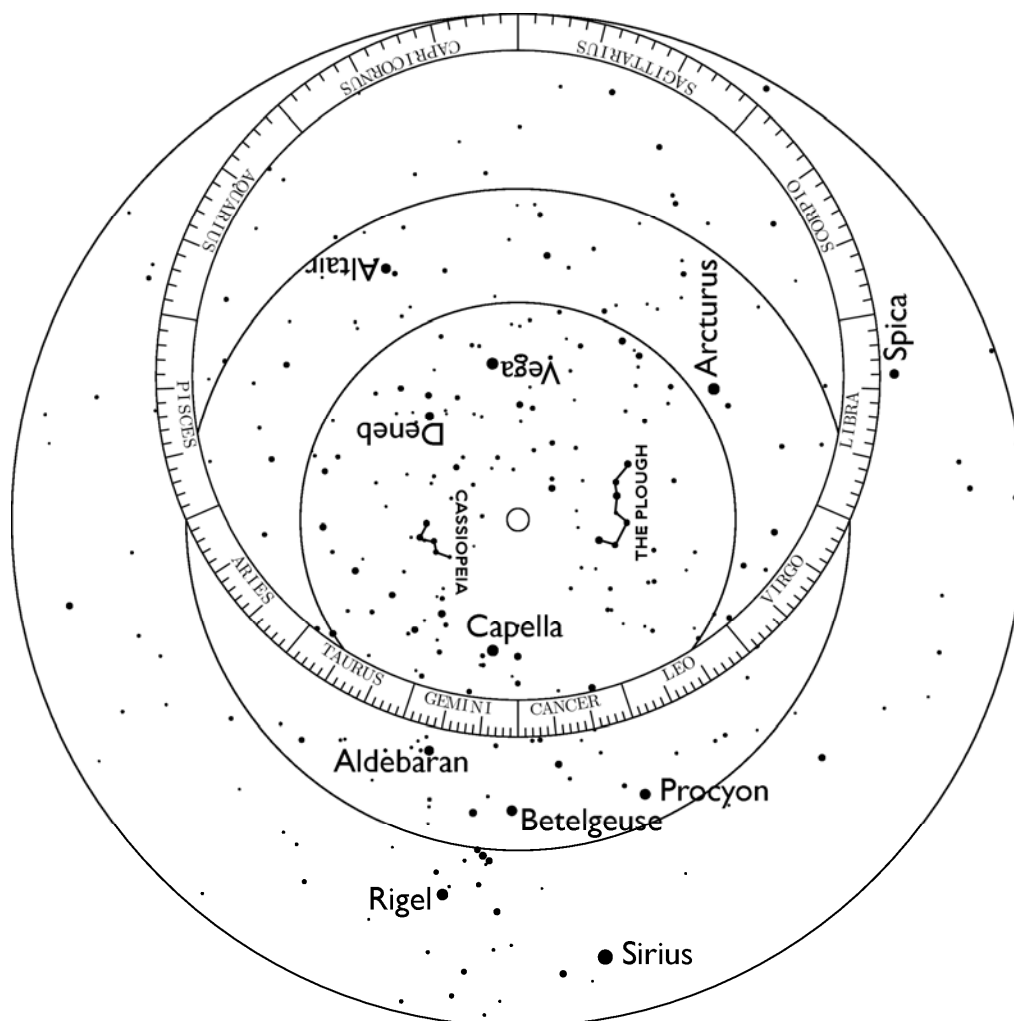
Astrolabe template page 3: Rete

Print this page on acetate

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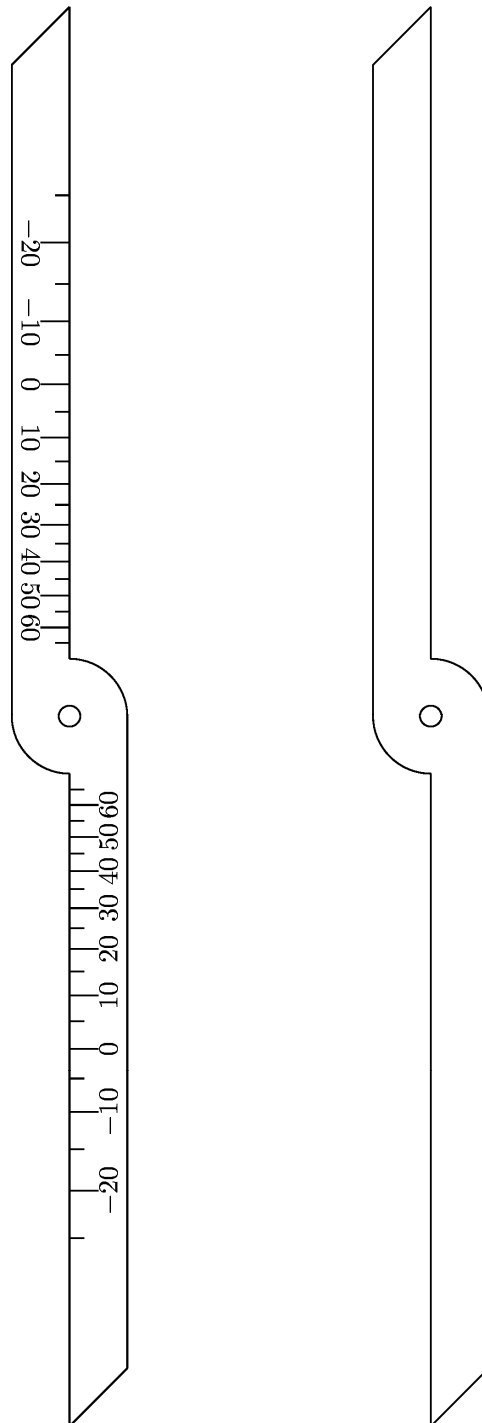
Astrolabe template: Rule and Label

Print this page on thin card

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You will need

* Astrolabe template (four pages)
* Scissors
* Glue
* A pen or pencil
* Split-pin paper fastener
* Ribbon or thin string

An extra circle of card, diameter 17cm, is also useful to strengthen the astrolabe.

What to do

1. Carefully cut out the parts from each page of the astrolabe template. You should have five pieces:

   Mother, back: A circular disk with a bulge at the top, marked with the months of the year, the signs of the Zodiac, and quarters each divided into 90 degrees.

   Mother, front: A circular disk with a bulge at the top, marked with the hours of the day and night (from 1 to midnight), and lines representing the sky.

   Rete: A circular disk printed on transparent acetate, marked with some stars and constellations

   Label: A thin pointer with no markings on it

   Rule: A thin pointer with a scale from -20 to 60 marked on it
2. Glue together the two sides of the mother, with a sheet of thicker card between them if possible. You can write your name on the front of the mother in the space indicated.
3. Make a hole through the centre of all the pieces, in the place indicated by the small circle.
4. Assemble the astrolabe with the label on the back of the mother, and the rete and then the rule on the front of the mother. Hold the astrolabe together with a split-pin paper fastener.
5. You should be able to rotate each of the label, rule and rete independently from each other.
6. Make a small hole in the top of the mother. Thread a small piece of ribbon through the hole, and tie the ends to make a loop. Thread another small piece of ribbon through this loop and tie it again into a loop. Now you can hang the astrolabe from your thumb.

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Star and Constellation Guide

Many stars have traditional names that have been used to describe them for thousands of years. Stars are today named officially according to order of brightness within each constellation. The brightest star in a constellation is named α (alpha, the first letter in the Greek alphabet), the second brightest is β (beta), and so on.

Aldebaran (α Tauri): the brightest star in the constellation of Taurus, and one of the brightest stars in the sky. Its name is derived from Arabic, and means "the follower", as it appears to follow the cluster of stars known as The Pleiades across the sky.

Altair (α Aquilae): the brightest star in the constellation of Aquila, the Eagle.

Arcturus (α Boötis): part of the constellation of Boötes. Its name comes from the ancient Greek Αρκτουρος (Arktourus), meaning "guardian of the bear". This name refers to its proximity to Ursa Major and Ursa Minor (the constellations of the Great and Little Bears).

Betelgeuse (α Orionis): a red giant star in Orion. Its red/orange colour is clearly visible with the naked eye.

Capella (α Aurigae): the third brightest star in the northern sky, and the brightest star in the constellation Auriga, the Charioteer.

Deneb (α Cygni): the brightest star in the constellation of Cygnus, the Swan. Its names comes from the Arabic for "tail". Other traditional names included Arided, Aridif and Gallina.

Procyon (α Canis Minoris): the seventh brightest star in the sky, and the brightest star in the small constellation of Canis Minor, The Small Dog. Although this is not visible with the naked eye, it is actually a binary star system: two stars orbiting each other at close distance.

Rigel (β Orionis): the sixth brightest star in the sky, a blue giant, 17 times more massive than our sun and about 40,000 times as luminous.

Siruis (α Canis Majoris): the brightest star in the sky. It forms part of the constellation Canis Major, the Great Dog, and was formerly often depicted as the nose of the dog, though today it's normally seen as part of the dog's neck. It is popularly known as the Dog Star.

Spica (α Virginis): the brightest star in the constellation Virgo. Its name is derived from the Latin "spica virginis", meaning "Virgo's ear of grain".

Vega (α Lyrae): the brightest star in the constellation Lyra, the Lyre, and the second brightest star in the northern sky.

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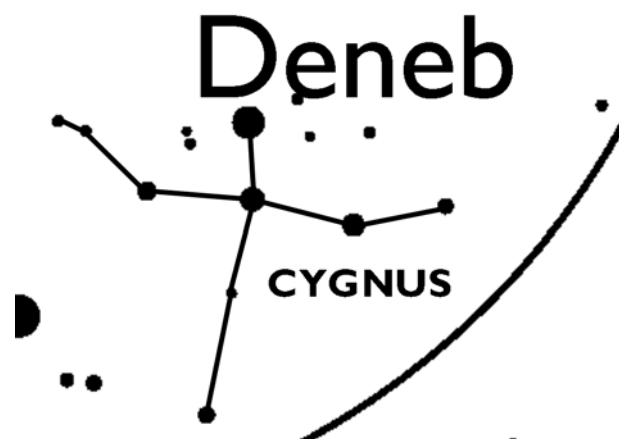
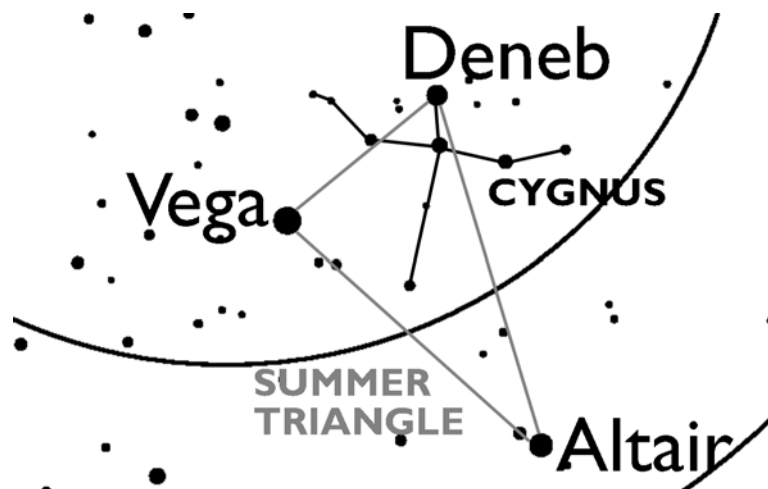
Constellations

Constellations are groups of stars that are identified by their similarity to objects, animals or mythical characters. They are a useful way of remembering where stars are and of navigating through the sky. They have no scientific meaning, because the stars in question may be at very different distances from earth; they just appear to be close together from our view point. To see some artistic representations of constellations visit http://www.joh.cam.ac.uk/library/library_photos/?album=the-way-to-the-stars-build-your-own-astrolabe.

The constellations as shown here and on the astrolabe are *mirror images* of those that you will see in the sky. This is because the astrolabe is drawn as if all the stars are located on a sphere at a great distance from earth. This was the medieval theory of the construction of the universe. Although we now know that the stars are all at different distances from earth, they are all an extremely long way away, so the older model still works in this instance. People on earth are, of course, viewing the stars from inside the sphere, so the constellations appear to be the other way round to the diagrams on the astrolabe.

Cygnus, The Swan

The brightest star in the constellation Cygnus is called Deneb. The constellation has the shape of a flying swan as seen from below (or above)

The Summer Triangle

The summer triangle is not an official constellation. It is a shape made from three bright stars easily visible during the summer months

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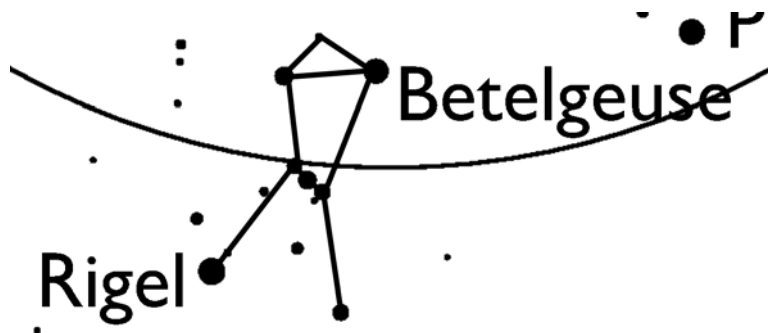
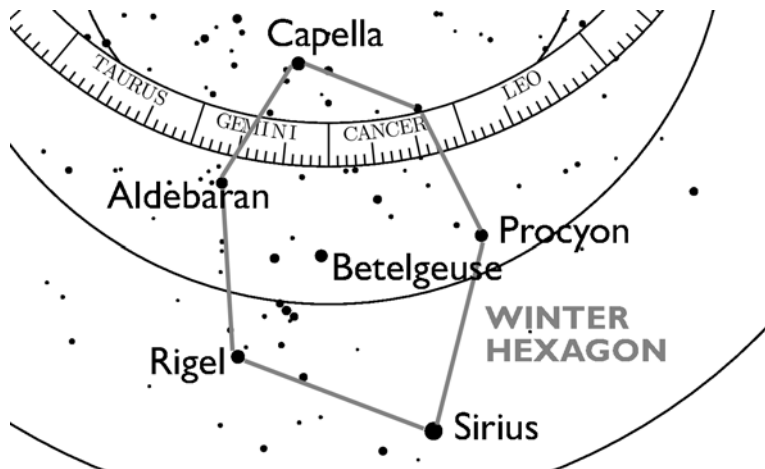
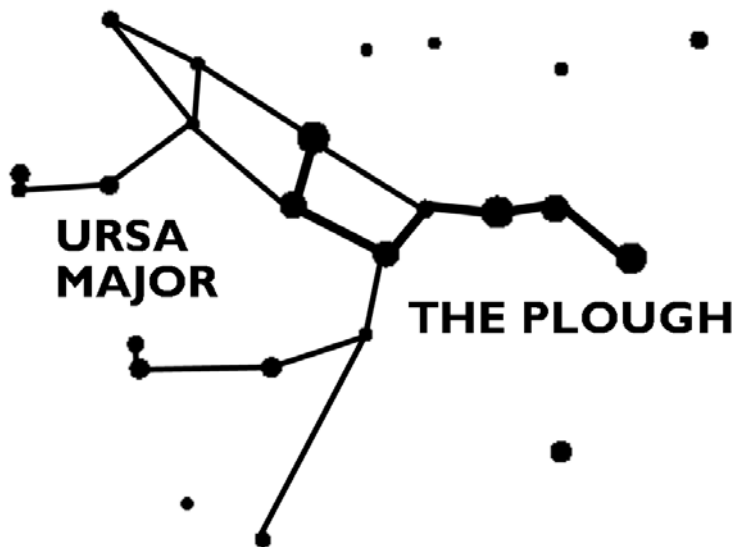
Orion, The Hunter
Orion is very easy to find on winter evenings. Look out for his distinctive belt of three stars, and the red colour of the star Betelgeuse.

The Winter Hexagon
Like the Summer Triangle, the winter hexagon is not an official constellation. As the name implies, it's a six-sided shape made from some of the brightest stars in the night sky.

The Plough
The famous star-shape known as The Plough, The Big Dipper, or The Saucepan isn't an official constellation in its own right. It's part of a bigger constellation called Ursa Major (The Great Bear). Here is a picture of The Plough as part of Ursa Major.

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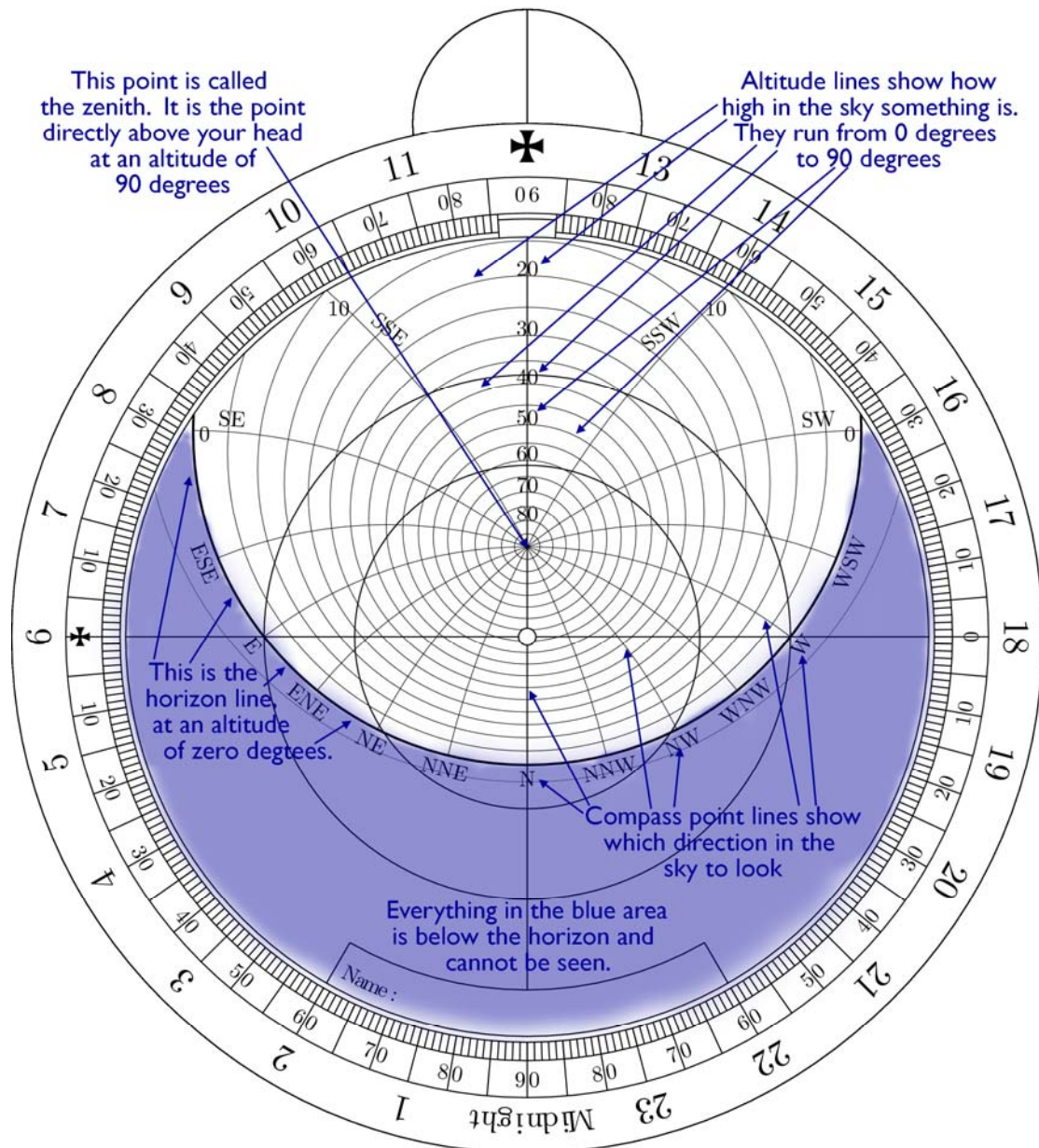
How to use your astrolabe

An astrolabe can give you information about lots of different things: the date, the time, and the location of objects (the sun or stars) in the sky. To use it, you need to set it up with the information you already know, and it will be able to supply an answer.

The date

We measure the date on the astrolabe using the constellations of the Zodiac. These are twelve constellations in sky through which the sun appears to move throughout the year. Astronomers have divided the sky into twelve equal parts that roughly match the position of these constellations, and then divided each part into 30.
To use the astrolabe we must be able to convert the date from a day in a month, e.g. 30 April, to a position in the Zodiac.

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To do this, use the back of the astrolabe. You will see that there is a ring showing all the months of the year, and another ring showing the positions in the Zodiac. To can convert one to the other by lining up the appropriate place with the label, and reading the numbers against each other. The 30 April is closest to 9 in Taurus. The Zodiac is divided into 360 parts and the year is divided into 365 (or 366) days, so the match will not always be exact.

Then you need to be able to identify that place on the each of the Zodiac marked on the rete. This place shows where the sun is at any given moment, day or night.

The time

The hours of the clock are marked around the edge of the front of the mother. The twenty-four hour clock is used, and it is based on Greenwich Mean Time (GMT). In the summer, you will need to take 1 hour away from the time of day to get the time in GMT (e.g. 7pm in the evening in July is 18 on the astrolabe as 7pm = 19 on the 24-hour clock, and one hour has to be taken away to reach GMT).

Height of an object in the sky

The astrolabe can be used to measure the elevation, also known as the height or altitude, of an object in the sky above the horizon:

1. Hang the astrolabe from your thumb, and hold it in front of your face so that the astrolabe is side-on to you, with the middle of the astrolabe in line with your eye.
2. Move the one of the pointers so that it lines up with the object you want to observe.
3. Keep the pointer in this position, then read off from the edge of the mother the angle of elevation of the object.
4. You can then use this information to work out other things, such as the time, date, or to identify what objection you're looking at.

On the front of the mother of the astrolabe, the height of objects above the horizon is shown by a series of concentric ovals marked with their height in degrees. 10° is just above the horizon, and 80° is nearly directly above your head.

Direction of an object

The astrolabe will tell you in which direction – North, East, South or West – to look for an object.

On the front of the mother you will see that the compass points and their divisions are marked with letters – N, NNE, NE, ENE, E, etc. These letters label lines that extend from the horizon line up to the zenith. These lines tell you in which direction an will appear. So if a star on the rete is on, or close to, the line labelled 'SE', look towards the south east to find it. The altitude lines will tell you whether to look near to the horizon or high above your head.

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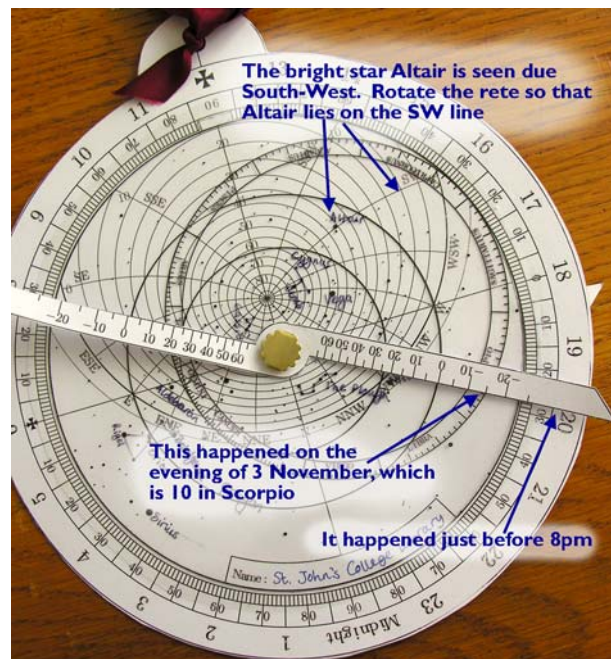
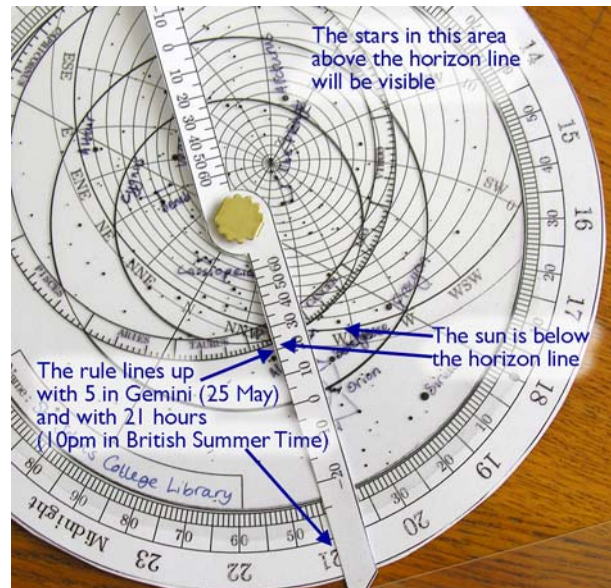
Now put all of this information together...

If you know the date and time and would like to know where the sun will be in the sky, line up the rule against the rete at the point in the Zodiac for the date in question.

Now rotate the rete and rule together until the rule points to the time of day. The position in the Zodiac that you just found will now be above the mother in the position of the sun at that time.

Use the altitude and direction lines to see where in the sky the sun will be. If the sun is outside the horizon line then the sun is below the horizon and it is night-time.

If you know where the sun is, but not what time it is, you place the rule on the position in the Zodiac for the date. Then move the rete and rule together until that position is at the right place in the sky. Now the rule will point to the time of day. Remember to that this is a 24-hour clock using GMT!

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Extension Questions and Tasks

What might stop you seeing the stars as shown on the astrolabe?
* cloud cover and hazy skies
* buildings, trees, or hills (though maybe not in Cambridgeshire!) in the way
* light pollution

How accurate do you think the astrolabe is?
What will affect its accuracy?
* accuracy of assembly - cutting out, hole placement etc.
* levels of accuracy of various parts: e.g. to nearest degree on protractor round edge, to nearest 5 degrees of altitude.
* the earth is not a perfect sphere and does not move perfectly regularly through the sky. This means that the astrolabe, which does not incorporate all of these eccentricities, cannot be a truly accurate model. It will become less accurate over time as the earth's position relative to the stars shifts in small, but perceptible amounts.
* the conversion between a date and a point in the Zodiac only allows for non-leap years, so in leap years it will be less accurate.

What can't the astrolabe do? Why not?
The astrolabe can't give you any information about the moon or the planets. Both the moon and planets change their positions relative to the stars all the time. In fact, the name 'planet' comes from a Greek word meaning "wanderer". The astrolabe would have to be far more complex in order to represent this movement.

Add more information to the rete:
The rete of the astrolabe is marked with about 300 of the brightest stars in the sky. Some of the brightest and most famous stars have been labelled with their names, and two of the most well-known constellations have been drawn in. You can add find out more about these stars and add other constellations using the Star and Constellation Guide. You will need to use a permanent, non-washable pen to write on the rete.

See medieval astrolabes on display in Cambridge:
Whipple Museum of the History of Science, Free School Lane, Cambridge, CB2 3RH
http://www.hps.cam.ac.uk/whipple/